

**METHOD AND APPARATUS FOR LINK ADAPTATION IN A MOBILE
COMMUNICATION SYSTEM**

PRIORITY

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This application is a Continuation Application of U.S. Patent Application No. 09/892,803 filed on June 27, 2001, which claims priority to an application entitled "Method and Apparatus for Link Adaptation in a Mobile Communication System" filed in the Korean Industrial Property Office on June 27, 2000 and
10 assigned Serial No. 2000-35792, the contents of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

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1. Field of the Invention

The present invention relates generally to a mobile communication system, and in particular, to a link adaptation apparatus and method in a CDMA (Code Division Multiple Access) mobile communication system.

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2. Description of the Related Art

In a mobile communication system using radio channels, an attenuation of a radio signal varies depending on a distance between an access network (AN) and an access terminal (AT), and shadowing. Further, the radio channels used in the mobile communication system experience considerable interference between
25 signals, and fading. Therefore, a carrier-to-interference ratio (hereinafter, referred to as "C/I" for short) is subjected to severe variations depending on the condition of the radio channels. A link adaptation technique has been proposed to increase throughput of a channel by adjusting a data rate according to the channel condition (or C/I). The data rate is determined depending on a coding rate and a
30 modulation mode. When the C/I is high, a higher coding rate and a high-level

modulation mode are used to increase the data rate. On the contrary, however, when the C/I is low, a lower coding rate and a low-level modulation mode are used to increase reliability of the channel.

5 In order to transmit data while maintaining the channel reliability according to the C/I, a receiver and a transmitter in the mobile communication system operate as follows. The receiver predicts a variation of the next channel based on the C/I to determine a data rate, and then, transmits the determined data rate information to the transmitter. The transmitter then assigns a data rate
10 according to the data rate requested by the receiver and maintains a transmission power level constantly to a reference level.

Measurement of the C/I and assignment of the data rate will be described below with reference to an HDR (High Data Rate) forward link proposed in
15 3GPP2 (3rd Generation Partnership Project 2), by way of example. In the foregoing description, the transmitter corresponds to an access network (AN), while the receiver corresponds to an access terminal (AT). The HDR physical layer based on the link adaptation technique supports 13 transmission modes, which are determined by a combination of three modulation modes of QPSK
20 (Quadrature Phase Shift Keying), 8PSK (8-ary Phase Shift Keying) and 16QAM (16-ary Phase Shift Keying), three coding rates of 1/4, 3/8 and 1/2, and the number of slots where a packet is repeated. The transmission power level of HDR system is the maximum transmission power level.

25 FIG. 1 illustrates a transmission/reception timing diagram of forward and reverse links in an HDR system. Referring to FIG. 1, the forward and reverse packets each include 2048 chips per slot. Further, each slot includes one pilot channel per half slot (1/2 slot), and each pilot channel includes 96 chips. Such a pilot channel is usually transmitted at the same power as that of a traffic channel.
30 Therefore, the HDR system estimates a C/I of the traffic channel by measuring a

C/I of the pilot channel. That is, the receiver measures a C/I value of the pilot channel and determines a data rate depending on the measured C/I value. The receiver transmits the determined data rate information to the transmitter. In the HDR specification, the data rate information transmitted to the transmitter is referred to as “DRC (Data Rate Control).” The DRC is transmitted over a DRC channel, and represented by a 4-bit DRC symbol.

FIG. 2 illustrates puncturing patterns of a pilot channel, a DRC channel and an RRI (Reverse Rate Indicator) channel for the reverse link of the HDR system. Here, the RRI channel is used to transmit data rate information of a reverse traffic channel. With reference to FIG. 2, a description will be made herein below of a structure of each channel for the reverse link.

First, a process for constructing a DRC symbol transmitted over the DRC channel will be described. The DRC symbol transmitted over the DRC channel is block-encoded with each code of (8,4,4) bi-orthogonal code on a one-to-one basis according to a data rate. Thereafter, the access terminal repeats an 8-bit DRC symbol transmitted over the reverse link, once every bit. Further, the access terminal spreads the repeated DRC symbol with an 8-bit Walsh code indicating a sector to which the access terminal belongs. The spread DRC symbol is spread again with a 4-bit Walsh code, constructing a DRC symbol comprised of a total of 512 chips. The 512-chip DRC symbol is repeated once again, so that each slot includes 1024 chips assigned to the DRC channel. The DRC chips are divided into 16 64-chip TDM (Time Division Multiplex) slots, and transmitted together with the pilot and RRI channels on a TDM basis, as shown in FIG. 2. That is, the DRC chips are alternately inserted starting from the first TDM slot. An RRI symbol is inserted once in the second TDM slot of a 2048-chip slot. Further, pilot symbols are inserted in the TDM slots into which the DRC symbols are not inserted, thereby constructing one slot.

Now, a description will be made regarding a process of determining a data rate depending on a C/I of the forward channel and a process of transmitting the DRC over the reverse channel in the HDR system employing the link adaptation technique.

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The HDR system supports several predefined data rates, and each data rate has a unique coding rate and a unique modulation mode. Further, the receiver includes a C/I table for storing a C/I threshold satisfying a specific packet error probability at every data rate. Therefore, the receiver measures a C/I value of the
 10 pilot channel among the forward channels, and compares the measured C/I value with the C/I thresholds stored in the C/I table. The receiver searches the largest one of the C/I thresholds that is smaller than the measured C/I value, and determines a corresponding data rate as an acceptable data rate. The receiver transmits the determined data rate information to the transmitter over the DRC
 15 channel out of the reverse channels.

There exists an interval between the adjacent C/I thresholds stored in the C/I table. Therefore, even though a C/I threshold closest to the C/I value is selected, there exists a difference between them. This difference becomes surplus
 20 transmission power on the C/I and the packet error probability. Therefore, transmitting a transmission channel at a data rate associated with the selected C/I threshold causes an unnecessary waste of transmission power.

Table 1 below illustrates a C/I table in which C/I thresholds are stored,
 25 by way of example. When the measured C/I value is -13dB, the receiver selects a C/I threshold of -15dB in accordance with Table 1. In this case, there exists a difference of 2dB between the measured C/I value and the selected C/I threshold.

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Table 1

Data Rate	C/I Threshold
38.4Kbps	-15dB
76.8Kbps	-12dB
...	...
2.4Mbps	+9dB

The C/I thresholds given in Table 1 satisfy a receiving error rate at each data rate. Therefore, the receiving error rate is duly satisfied even for the C/I value of -15dB. However, when the C/I value is -13dB, there occurs surplus power of -2dB, causing an unnecessary waste of power during data transmission. In addition, the surplus power causes interference between channels and a waste of bandwidth.

10 In conclusion, since the HDR system employing the link adaptation technique determines a data rate by comparing the C/I value with predetermined C/I thresholds, there occurs a difference between the actual C/I value measured and the C/I threshold that becomes a criterion for determining the data rate. The difference causes an unnecessary waste of power at the transmitter, increases
15 interference between channels in the radio environment, and causes a waste of bandwidth.

SUMMARY OF THE INVENTION

20 It is, therefore, an object of the present invention to provide an apparatus and method for reducing surplus transmission power in a mobile communication system employing link adaptation.

It is another object of the present invention to provide an apparatus and method for indicating a data rate and a transmission power level in a mobile communication system employing link adaptation.

- 5 It is further another object of the present invention to provide an apparatus and method for transmitting a C/I value of a forward channel to a transmitter in a mobile communication system employing link adaptation.

According to one aspect of the present invention, there is provided a
10 method for determining a forward data rate and a forward transmission power level in a mobile communication system. An access terminal measures a C/I of a forward pilot channel, determines a forward data rate by matching the measured C/I with a reference C/I, creates a difference between the measured C/I and the reference C/I as margin information, and transmits the determined forward data
15 rate and margin information over a reverse transmission channel. Upon receipt of the forward data rate and margin information, an access network decreases a transmission power level by power corresponding to the margin information and performs forward transmission at the forward data rate at the decreased transmission power level.

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According to another aspect of the present invention, there is provided a method for determining a forward data rate and a forward transmission power level in a mobile communication system. An access terminal measures a C/I of a forward pilot channel, and transmits the measured C/I over a reverse data rate
25 channel. Upon receipt of the C/I received over a reverse link, an access network determines a forward data rate by matching the measured C/I with a reference C/I associated with a data rate of packet data, determines margin information for determining a forward transmission power level by calculating a difference between the received C/I and the reference C/I when the received C/I is not
30 identical to the reference C/I, creates transmission data associated with the

determined data rate, decreases the transmission power level associated with the data rate using the calculated margin information, and transmits the transmission data at the decreased transmission power level.

- 5 According to further another aspect of the present invention, there is provided a transmission apparatus for a mobile communication system, for determining a data rate using a C/I and transmitting a forward data rate and a transmission power level over a reverse transmission channel using margin information determined based on a difference between a reference C/I and the C/I.
- 10 The apparatus comprises: a first multiplexer for time-division-multiplexing the data rate and the margin information; an encoder for encoding an output of the first multiplexer; a spreader for spreading the encoded data rate and margin information; and a second multiplexer for time-division-multiplexing a reverse pilot channel and an RRI (Reverse Rate Indicator) channel to an output of the
- 15 spreader.

 According to yet another aspect of the present invention, there is provided a transmission apparatus for transmitting a C/I in a mobile communication system. The apparatus comprises: an encoder for encoding a

20 measured C/I; a spreader for spreading an output of the encoder; and a multiplexer for time-division-multiplexing an output of the spreader, a reverse pilot channel and an RRI channel.

BRIEF DESCRIPTION OF THE DRAWINGS

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The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings in which:

FIG. 1 illustrates a transmission/reception timing diagram of forward and

30 reverse links in an HDR system;

FIG. 2 illustrates puncturing patterns of a pilot channel, a DRC channel and an RRI channel for a reverse link in the HDR system;

FIG. 3 illustrates a procedure for determining a forward data rate and a transmission power level based on DRC and C/I margin according to a first
5 embodiment of the present invention;

FIG. 4A illustrates a slot transmission/reception timing diagram of forward and reverse links, wherein a DRC symbol and a C/I margin symbol are transmitted over two slots according to the first embodiment of the present invention;

10 FIG. 4B illustrates a slot transmission/reception timing diagram of forward and reverse links, wherein a DRC symbol and a C/I margin symbol are transmitted over one slot according to the first embodiment of the present invention;

FIG. 5 illustrates a structure of an access terminal transmitter for
15 transmitting a DRC symbol and a margin symbol in the method as illustrated in FIG. 4A;

FIG. 6 illustrates a procedure for determining a forward data rate and a transmission power level based on a C/I value according to a second embodiment of the present invention;

20 FIG. 7A illustrates a slot transmission/reception timing diagram of forward and reverse links, wherein an 8-bit C/I symbol is transmitted over one slot according to the second embodiment of the present invention;

FIG. 7B illustrates a slot transmission/reception timing diagram of forward and reverse links, wherein an 8-bit C/I symbol is transmitted over two
25 slots according to the second embodiment of the present invention; and

FIG. 8 illustrates a structure of an access terminal transmitter for transmitting a C/I symbol as illustrated in the method of FIG. 7A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention will be described herein below with reference to the accompanying drawings. In the following description, 5 well-known functions or constructions are not described in detail since they would obscure the invention in unnecessary detail.

In the following description, the term “forward link” is defined as a radio link formed in a direction from an access network AN to an access terminal AT, 10 while the term “reverse link” is defined as a radio link formed in a direction from the access terminal AT to the access network AN. In addition, the term “DRC (Data Rate Control)” is defined as information on a data rate requested by a receiver.

15 FIG. 3 illustrates a procedure for determining a forward data rate and a transmission power level based on DRC and C/I margin according to a first embodiment of the present invention. Referring to FIG. 3, an access terminal AT measures a C/I value of a forward pilot channel in step S110. Thereafter, in step S120, the access terminal AT searches the C/I table of Table 1 for the largest one 20 of the C/I thresholds that is smaller than the measured C/I value, and defines the selected C/I threshold as a reference C/I. Here, the “reference C/I” refers to a C/I threshold selected, based on the measured C/I value, from the C/I thresholds previously stored in the C/I table. After selecting the reference C/I value in step S120, the access terminal AT defines a data rate associated with the reference C/I 25 value in the C/I table as an acceptable data rate and then, constructs the determined data rate into a 4-bit DRC symbol, in step S130.

In step S140, the access terminal AT calculates the difference between the measured C/I value and the reference C/I value. The calculated difference 30 value becomes a margin value. Since the largest one of the C/I thresholds that is

smaller than the measured C/I value is selected from the C/I table, the difference obtained by subtracting the reference C/I value from the measured C/I value always has a positive value. Further, in step S140, the access terminal AT converts the calculated margin value into margin information comprised of a
5 predetermined number of data bits. For example, if the margin information is divided into 16 levels, it can be comprised of 4 data bits. That is, the access terminal AT creates a 4-bit margin symbol using the calculated margin information. In step S150, the access terminal AT encodes the DRC symbol and the margin symbol, and transmits the encoded symbols to an access network AN.

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The DRC symbol and the margin symbol are transmitted from the access terminal AT to the access network AN through a radio link. Then, in step S160, the access network AN decodes the received DRC and margin symbols. The decoded DRC symbol is provided to a scheduler included in the access network
15 AN, while the decoded margin symbol is provided to a transmission amplifier included in the access network AN. Then, in step S170, the access network AN determines an access terminal to be assigned a traffic channel of the next slot and also determines a data rate of the determined access terminal, based on the DRC symbol. In step S180, the transmission amplifier of the access network AN
20 defines as a power level a value determined by decreasing the transmission power level by the power level calculated from the margin symbol. Therefore, the forward traffic channel transmits its traffic data at the transmission power level set according to the data rate, reduced by the transmission power level according to the margin symbol. Unlike the traffic channel, the forward pilot
25 channel and a forward MAC (Media Access Control) channel are transmitted at a constant transmission power level regardless of the data rate or the margin. The access terminal AT measures the C/I value not depending on the transmission power level updated according to the margin symbol but depending on the constant transmission power level.

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In the first embodiment of the present invention, the access terminal AT transmits the DRC symbol and the margin symbol to the access network AN through the DRC channel of the HDR reverse link, as described with reference to FIG. 2.

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With reference to FIGs. 4A and 4B, a description will be made of two proposed methods for transmitting the DRC and margin symbols. FIG. 4A illustrates a slot transmission/reception timing diagram of forward and reverse links, wherein a DRC symbol and a C/I margin symbol are transmitted over two slots according to the first embodiment of the present invention. FIG. 4B illustrates a slot transmission/reception timing diagram of forward and reverse links, wherein a DRC symbol and a C/I margin symbol are transmitted over one slot according to the first embodiment of the present invention.

15 In FIG. 4A, a DRC symbol and a C/I margin symbol are alternately transmitted over 2 slots through a DRC channel of the HDR reverse link. That is, after measuring the C/I value of the pilot channel of the HDR forward link AN_Tx and determining a 4-bit DRC symbol and a 4-bit C/I margin symbol accordingly, the HDR reverse link AT_Tx transmits the 4-bit DRC symbol in the 20 odd-numbered slot duration among the 32 slots constituting one packet, and transmits the 4-bit C/I margin symbol corresponding to the just-transmitted DRC symbol in the even-numbered slot duration.

The access network AN receives the DRC symbol and the margin symbol in a unit of two slots, and then, determines a data rate to be applied to the 25 next slot of the forward link and a transmission power level of the traffic channel. Therefore, in the example of FIG. 4A, scheduling in the forward link is performed in a unit of two slots, and the C/I value is also determined using a C/I value of a received pilot channel of two slots.

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In FIG. 4B, the DRC symbol and the C/I margin symbol are transmitted over one slot through the DRC channel of the HDR reverse link. A general DRC symbol is repeated once within one slot after spreading. However, the reverse link AT_Tx according to the present invention alternately transmits the 4-bit DRC symbol and the 4-bit margin symbol in a unit of half slot, instead of repeating the 4-bit DRC symbol. That is, the 4-bit DRC symbol is transmitted in the first half duration of one slot, while the 4-bit margin symbol is transmitted in the second half duration. In the example of FIG. 4B, scheduling is performed in a unit of one slot, but the transmission power level of the reverse link must be doubled in order to maintain the error probability of the method shown in FIG. 4A.

FIG. 5 illustrates a structure of an access terminal transmitter for transmitting the DRC symbol and the margin symbol as described in the method of FIG. 4A. Referring to FIG. 5, a first multiplexer (MUX) 131 outputs the 4-bit DRC symbol in the odd-numbered slot duration, and outputs the 4-bit margin symbol in the even-numbered slot duration. The DRC symbol or the margin symbol output from the first multiplexer 131 is subjected to (8,4,4) bi-orthogonal coding by a block encoder 132, and then, repeated once by a repeater 133. The output signals of the repeater 133 are primarily spread with a Walsh code W_0^2 of length 2 by a first spreader 134, and then, secondarily spread by a second spreader 135 with a Walsh code W_i^8 selected by 3-bit index information 'i' of the sector to which the access terminal belongs. Further, the secondarily spread signals are finally spread with a Walsh code W_0^4 of length 4 by a third spreader 136. That is, the signals output from the block encoder 132 are subjected to spreading three times.

Meanwhile, a pilot channel is spread with a Walsh code W_0^4 of length 4 by a pilot spreader 101. Further, 3-bit RRI information is orthogonally modulated by an orthogonal modulator 111, and repeated by a Walsh symbol repeater 113.

Thereafter, the output signal of the Walsh symbol repeater 113 is spread with a Walsh code W_0^4 of length 4 by an RRI spreader 115.

A second multiplexer 137 multiplexes the spread pilot channel, the spread RRI channel and the spread DRC or margin symbol on a TDM basis. A complex spreader 146 performs complex spreading on the output of the second multiplexer 137 and the traffic/control channel signals spread with a Walsh code W_2^4 of length 4 by a traffic channel spreader 145. The complex spread signal is baseband-filtered by a baseband filter 147, and then, transmitted to the access network AN.

When the structure of FIG. 5 is applied to FIG. 4B, the 4-bit DRC symbol and the 4-bit margin symbol are spread without repetition after being subjected to bi-orthogonal coding. That is, the transmitter is not required to include the repeater 133 in transmitting the DRC symbol and the margin symbol.

FIG. 6 illustrates a procedure for determining a forward data rate and a transmission power level based on a C/I value according to a second embodiment of the present invention. Referring to FIG. 6, an access terminal AT measures a C/I value of a forward pilot channel in step S210. Thereafter, in step S220, the access terminal AT constructs the measured C/I value into an 8-bit C/I symbol, encodes the constructed symbol, and then transmits the encoded symbol to an access network AN. That is, the access terminal AT creates the measured C/I value into an 8-bit symbol instead of the 4-bit DRC information as in the prior art and the first embodiment of the present invention.

In step S230, the access network AN receives the C/I symbol and decodes the received C/I symbol. Thereafter, in step S240, the access network AN searches the C/I table for the largest one of the C/I thresholds that is smaller than the received C/I value, and defines this value as a reference C/I value. After

determining the reference C/I value, the access network AN selects a data rate corresponding to the reference C/I value from the C/I table and provides the selected data rate to a scheduler included therein, in step S250. The scheduler in the access network AN then defines the selected data rate as a data rate of the
5 traffic channel in the next slot of the corresponding access terminal AT.

Thereafter, in step S260, the access network AN calculates a margin of the C/I value against the reference C/I value. The margin is equal to a value determined by subtracting the reference C/I value from the C/I value, as in the
10 first embodiment. In step S270, the access network AN defines as a transmission power level a value determined by decreasing the transmission power level by a power level calculated according to the margin. After determining the power level, the access network AN provides the transmission power level value to the transmission amplifier included therein and uses it as a transmission power level
15 of the traffic channel in the next slot of the corresponding access terminal. Therefore, the forward traffic channel is transmitted at the determined transmission power level. Meanwhile, the forward pilot channel and the forward MAC channel are transmitted at the constant power level regardless of the data rate or the margin, as in the first embodiment.

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In the second embodiment of the present invention, since the access network AN determines the data rate by searching the C/I table, the access terminal AT is not required to transmit the DRC to the access network AN. Instead, the access terminal AT should transmit the measured C/I value to the
25 access network AN. However, since the C/I value needs more bits as compared with the DRC symbol, another method for transmitting the C/I value over the DRC channel of the HDR reverse link is required.

There are two proposed methods for transmitting the C/I symbol over the
30 DRC channel of the HDR reverse link according to the second embodiment of

the present invention. FIG. 7A illustrates the first method for transmitting the C/I symbol over the DRC channel of the reverse link according to the second embodiment of the present invention, while FIG. 7B illustrates the second method.

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FIG. 7A illustrates a slot transmission/reception timing diagram of forward and reverse links, wherein an 8-bit C/I symbol is transmitted over one slot according to the second embodiment of the present invention. With reference to FIG. 7A, the timing of transmitting the C/I symbol over the DRC channel of the reverse link according to the present invention will be described below.

In the prior art described above, the DRC symbol applied to the HDR system is comprised of 4 bits and is repeated once before transmission. In the second embodiment of the present invention, however, the leading 4 bits and the following 4 bits of the 8-bit C/I symbol are transmitted in a unit of half slot, instead of repeating the 4-bit DRC symbol within one slot. Therefore, the whole 8-bit C/I symbol is transmitted over only one slot. Herein, the leading 4 bits of the C/I symbol are transmitted in the first half-slot duration, while the following 4 bits of the C/I symbol are transmitted in the second half-slot duration. By doing so, the access network AN performs scheduling in a unit of one slot.

FIG. 7B illustrates a slot transmission/reception timing diagram of forward and reverse links, wherein an 8-bit C/I symbol is transmitted over two slots according to the second embodiment of the present invention. With reference to FIG. 7B, the timing of transmitting the C/I symbol over the DRC channel of the reverse link according to the present invention will be described below.

The 8-bit C/I symbol is divided into leading 4 bits and following 4 bits, and the leading 4 bits and the following 4 bits are alternately transmitted over

two slots in a unit of one slot. Specifically, the leading 4 bits of the C/I symbol are transmitted in the odd-numbered slot durations among the 16 slots constituting one packet, while the following 4 bits of the C/I symbol are transmitted in the even-numbered slot durations. Hence, the method of FIG. 7B
 5 requires two slots in transmitting the entire C/I symbol, but can transmit the C/I symbol at the half power compared with the method of FIG. 7A.

FIG. 8 illustrates a structure of an access terminal transmitter for transmitting the C/I symbol as described in the method of FIG. 7A. Referring to
 10 FIG. 8, an 8-bit C/I symbol is subjected to (8,4,4) bi-orthogonal coding by a block encoder 231. The output of the block encoder 231 is spread without repetition. Here, the spreading is performed in three steps. That is, the output of the block encoder 231 undergoes primary spreading with a Walsh code W_0^2 of length 2 by a first spreader 233, secondary spreading with a Walsh code W_i^8
 15 selected by 3-bit index information 'i' by a second spreader 235, and finally, third spreading with a Walsh code W_0^4 of length 4 by a third spreader 237.

Meanwhile, a pilot channel is spread with a Walsh code W_0^4 of length 4 by a pilot spreader 201. Further, 3-bit RRI information is orthogonally modulated
 20 by an orthogonal modulator 211, and repeated by a Walsh symbol repeater 213. Thereafter, the output signal of the Walsh symbol repeater 213 is spread with a Walsh code W_0^4 of length 4 by an RRI spreader 215.

A multiplexer 239 multiplexes the spread pilot channel, the spread RRI
 25 channel and the spread C/I symbol on a TDM basis. A complex spreader 246 performs complex spreading on the output of the multiplexer 239 and the traffic/control channel signals spread with a Walsh code W_2^4 by a traffic channel spreader 245. The complex spread signal is baseband-filtered by a baseband filter 247, and then, transmitted to the access network AN.

When applied to FIG. 7B, the structure of FIG. 8 is required to have a multiplexer arranged at the front stage of the block encoder 231, and a repeater arranged at the following stage of the block encoder 231. Thus, when transmitting the data as illustrated in the method of FIG. 7B, the multiplexer
5 multiplexes the leading 4 bits and the following 4 bits of the C/I symbol on a TDM basis. Therefore, the leading 4 bits are transmitted in the first half-slot duration, while the following 4 bits are transmitted in the second half-slot duration. In addition, the block-encoded signal output from the block encoder 231 is repeated once by the repeater. Thereafter, the three-step spreading
10 operation is performed in the same manner.

As described above, it is possible to reduce the surplus transmission power by applying the present invention to the mobile communication system employing the link adaptation technique. The reduction in surplus transmission
15 power contributes to decreasing interference to other sectors and other signals, and increasing a forward system capacity.

While the invention has been shown and described with reference to a certain preferred embodiment thereof, it will be understood by those skilled in
20 the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.